

INELASTIC PROTON SCATTERING TO UNNATURAL PARITY STATES IN EVEN MASS NUCLEI

B.M. Spicer,* V.C. Officer,* G.G. Shute,* K.A. Amos,* R.S. Henderson,*
D.W. Devins, D.L. Friesel and W.P. Jones

Inelastic proton scattering at energies in excess of 100 MeV is potentially a powerful tool for spectroscopic studies of excited nuclear states. Given that the reaction mechanism is known (that is, it is direct), and that the required optical model parameters can be derived from analysis of elastic scattering, the spectroscopy of the excited residual state will influence in a major way the calculation of the differential cross section. The other factor which enters is the two nucleon

interaction, and by studying the population of unnatural parity states, the focus is placed on the spin-flip component of the nucleon-nucleon interaction. Moreover, as unnatural parity transitions are usually well described by model spectroscopies, no enhancement factors (core polarization corrections) are required. Thus data reflect ostensibly only the two nucleon t-matrix aspects of the reaction mechanism.

Inelastic proton scattering from carbon

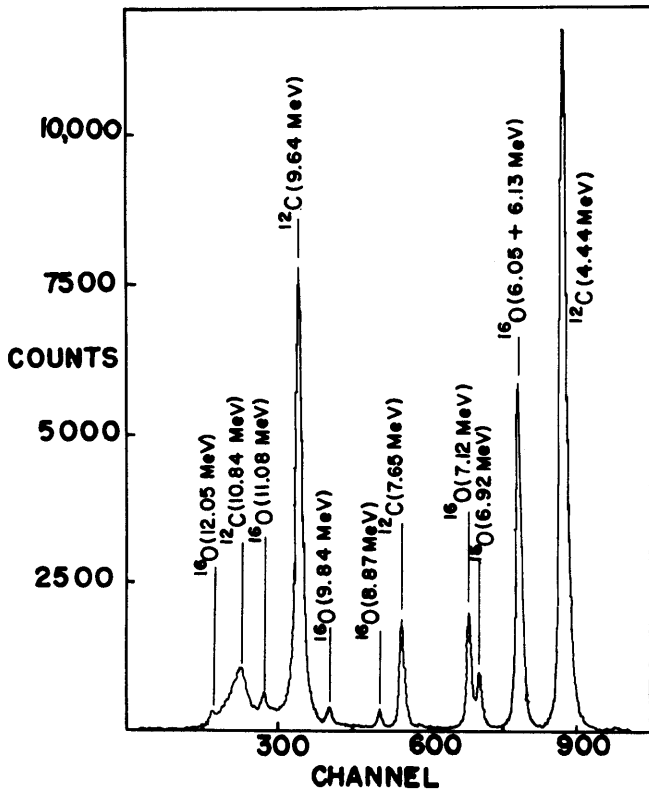


Figure 1. Spectrum of protons scattered inelastically from ^{12}C and ^{16}O at 30° - low excitation region. The states populated are indicated.

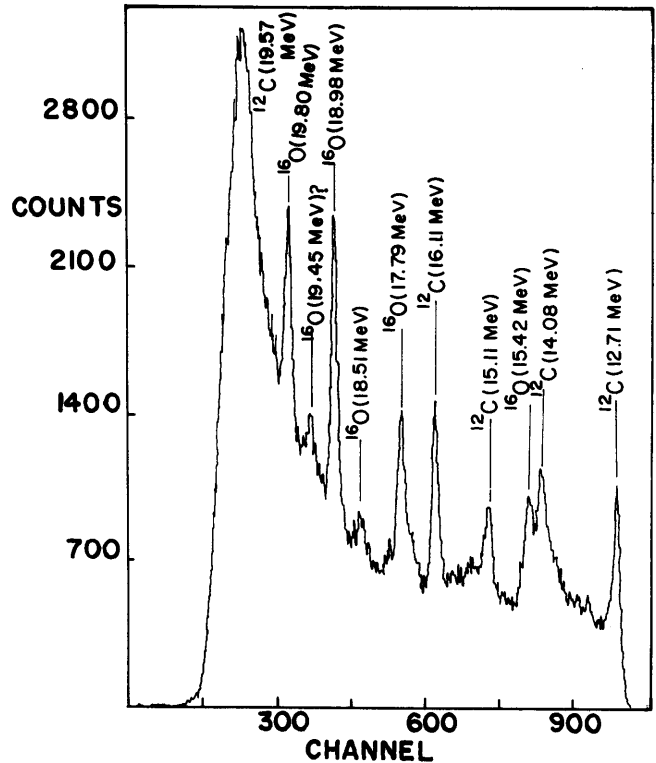


Figure 2. Spectrum of protons scattered inelastically from ^{12}C and ^{16}O at 35° - high excitation region. The states populated are indicated.

and oxygen, using a mylar target, has been studied between 25° and 85° , for a proton bombarding energy of 135 MeV. The detector used is the QDDM spectrograph, including the focal plane detector developed at the University of Melbourne,¹⁾ and two plastic scintillators for particle identification. The scattered proton spectra were measured with an energy resolution of about 90 keV.

Two ranges of excitation energy in ^{16}O have been covered over the angular range noted above. These are 5-10 MeV, and 15-20 MeV. Typical spectra taken in these two excitation regions are shown in Figures 1 and 2.

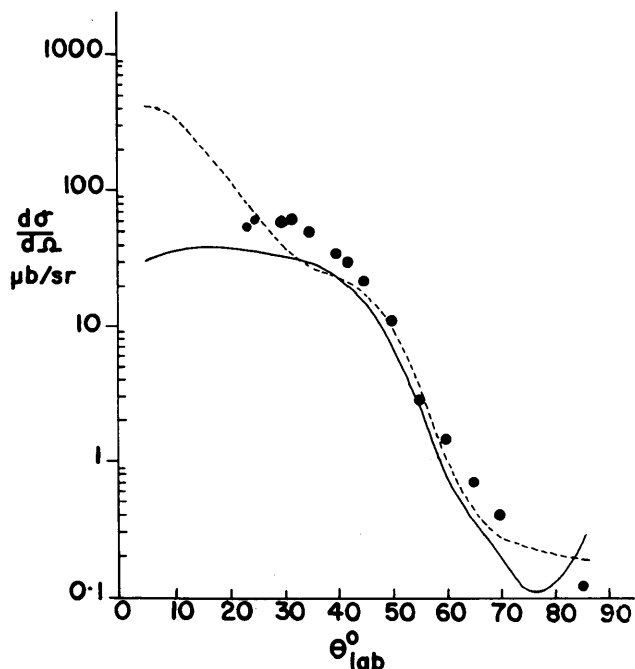


Figure 3. Two theoretical distorted wave fits to the differential cross section for the $^{16}\text{O}(p,p')$ reaction leaving the ^{16}O nucleus in its 8.87 MeV (2^-) state. The fits are for two different assumed spectroscopies of the 2^- state.

The lower excitation region contains the 2^- state of ^{16}O at 8.87 MeV, which is of interest as described above. A calculation of the differential cross section for inelastic proton scattering to this state, assuming two different spectroscopies for the 2^- state, is shown in Fig. 3. It is clear that measurements at angles less than 25° are necessary to distinguish between the two; these measurements will be made in the near future.

The higher excitation spectra also show very distinct peaks, but in this case the continuum background is quite large. Peaks corresponding to well-known states of ^{12}C are seen. It is most interesting that the three most prominent peaks associated with ^{16}O correspond to levels not listed by Ajzenberg-Selove.²⁾ They do, however, correspond very precisely in excitation energy with states seen in the single nucleon pickup reactions $^{17}\text{O}(d,t)^{16}\text{O}$ and $^{17}\text{O}(^3\text{He},\alpha)^{16}\text{O}$.³⁾ On the basis of those studies, and two independent calculations,^{4,5)} the states at 19.80 and 18.98 MeV excitation are assigned $J^\pi;T$ of $4^-;0$ and $4^-;1$ respectively. On these same bases, the state at 17.79 MeV is 4^- or 2^- , and the failure of the structure calculations to place a third 4^- state below 25 MeV excitation means that the probable spin and parity is 2^- . The isospin is not yet known. Calculations of the differential cross section for inelastic scattering to these states is proceeding.

For the two 4^- states, the immediate configuration suggested is $[(1d_{5/2})(1p_{3/2})^{-1}]_{4^-}$, and the calculations of Sanchez-Dehesa⁶⁾ indicate that this configuration has amplitude in excess of 0.95 in each of these states.

*School of Physics, University of Melbourne

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